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EP 0295368 A

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INT CL[5] G05G 9/04, G06F 3/033, G06K 11/16
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(54) **Capacitative puck**

(57) A control device for a computer comprises a puck 10 which slides on the surface of a platter 12, the position of the puck 10 being detected capacitatively. A pillar 14 extends through an aperture 13 in the platter and carries a capacitative plate 17 which moves relative to a plurality of capacitative plates 18 on a fixed facing part of the platter. The puck may incorporate one or more push buttons, depression of which may also be detected capacitatively. The puck may input rotary information in additional to translational information (Figs. 9-11). The puck may be arranged on a surface with separate switches so that the puck can be actuated by the user's index finger while the switches are actuated by the thumb and other fingers (Fig. 20). The puck may be built into a keyboard (Fig. 21). It is stated that the position of a joystick, trackerball or mouse may be detected capacitatively. The surface on which the puck slides may become increasingly sloped towards its boundary and the response may be non-linear as the puck approaches the boundary.

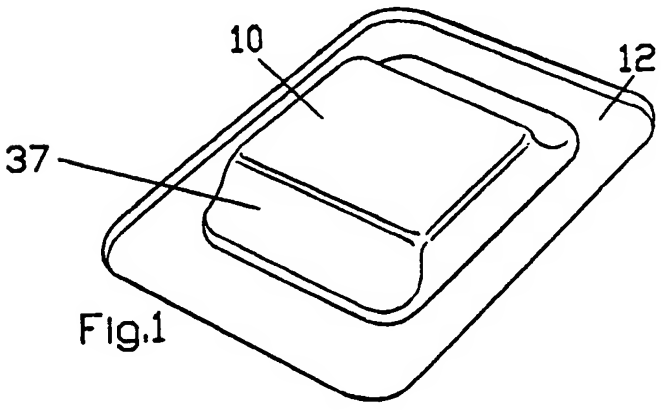

Fig.1

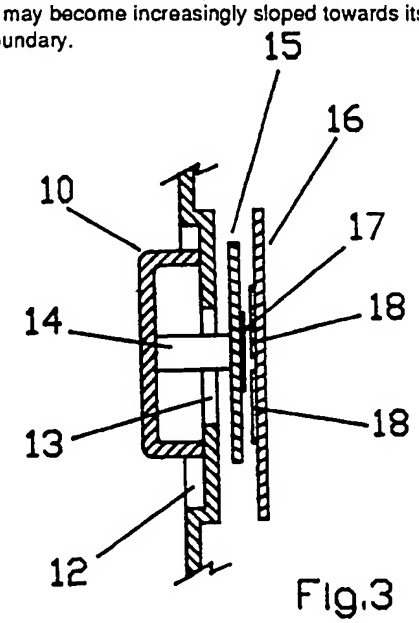

Fig.3

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

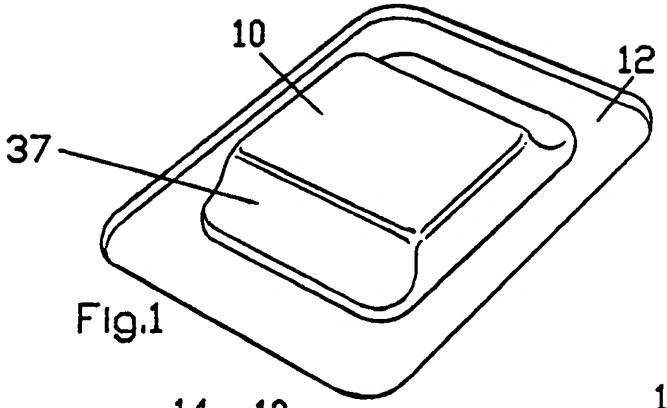

Fig.1

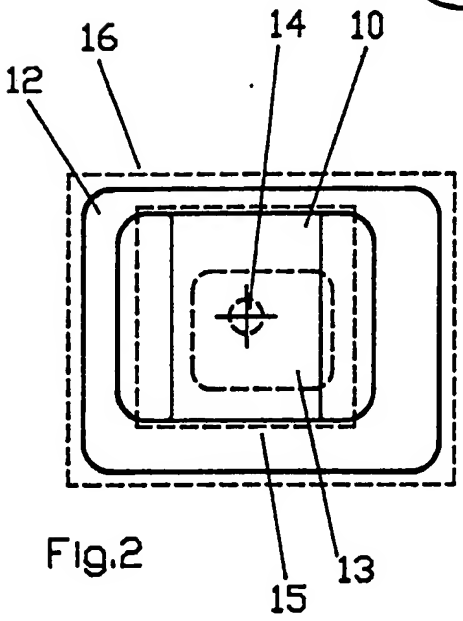

Fig.2

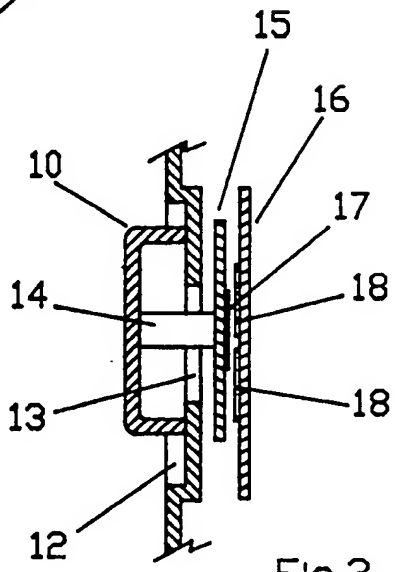

Fig.3

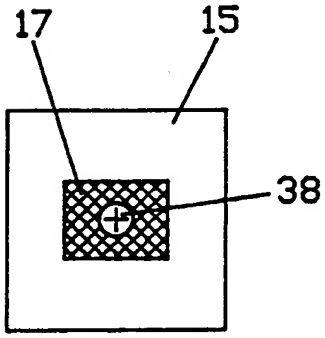

Fig.4

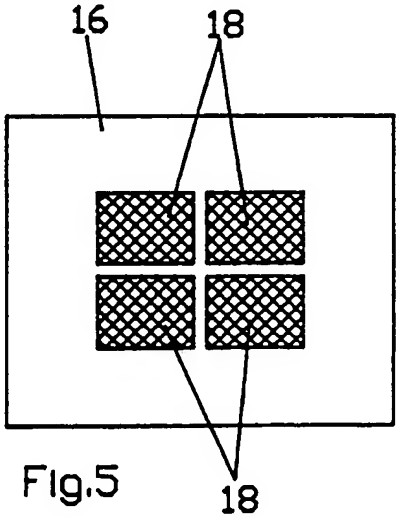

Fig.5

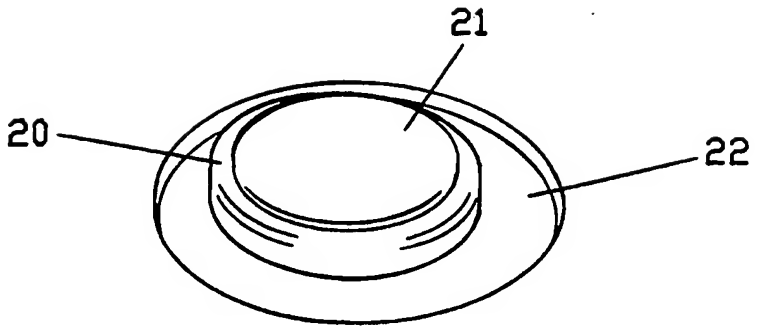

Fig.6

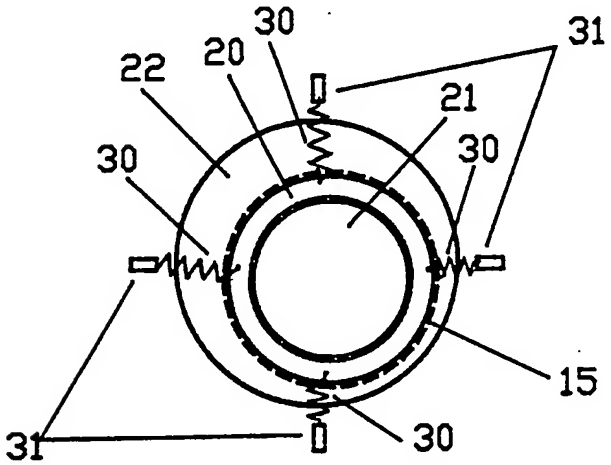

Fig.7

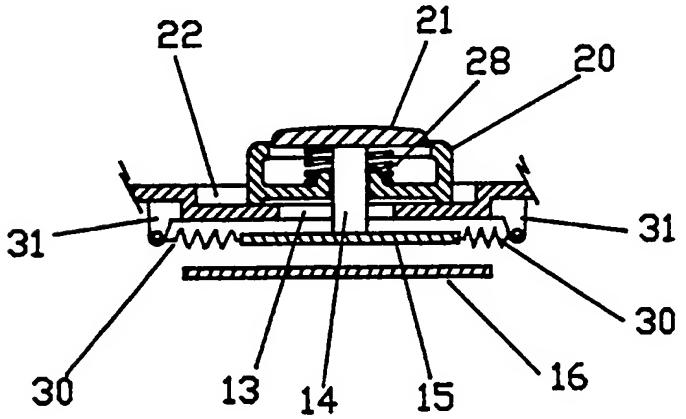

Fig.8

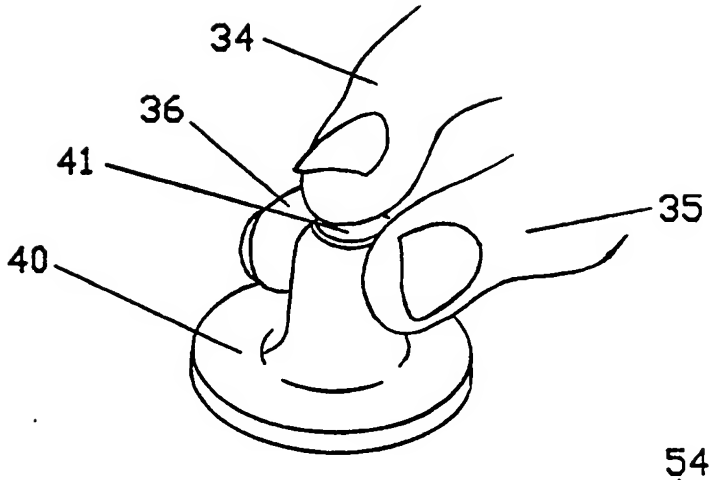

Fig.9

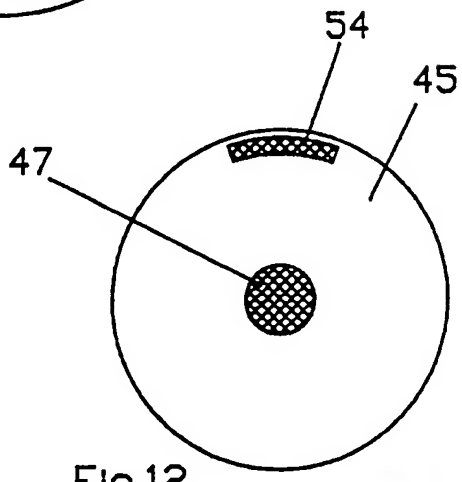

Fig.12

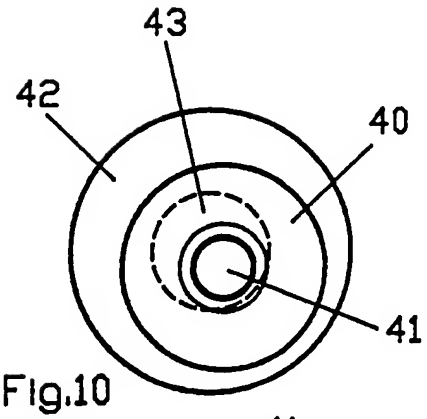

Fig.10

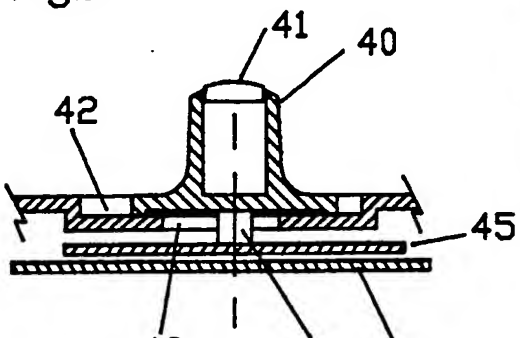

Fig.11

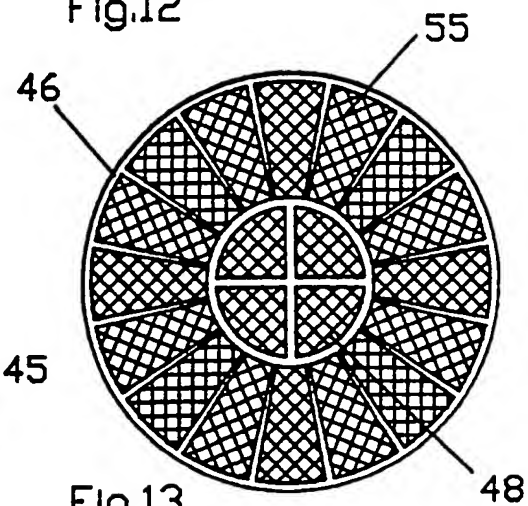

Fig.13

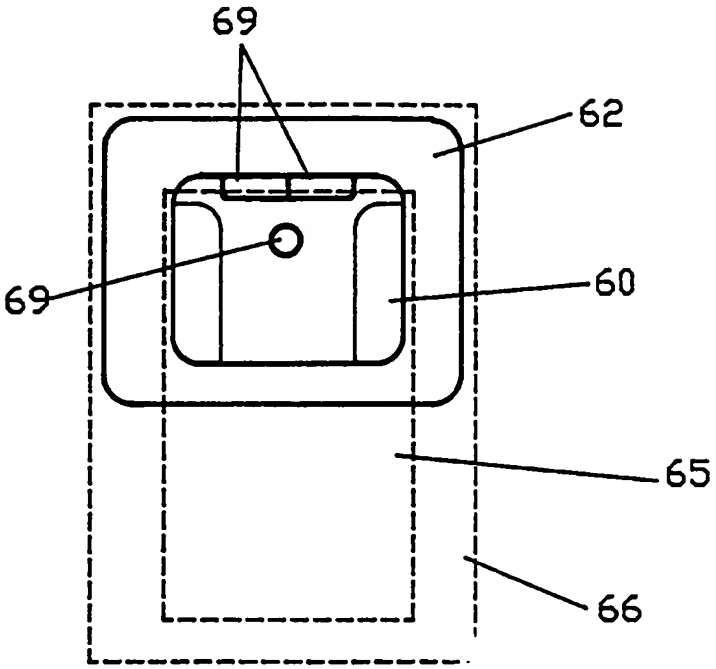

Fig.14

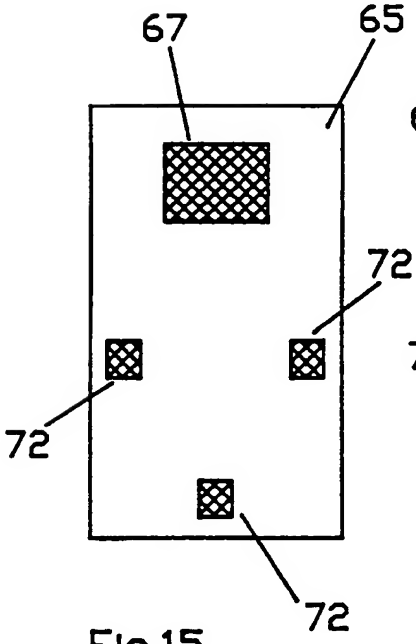

Fig.15

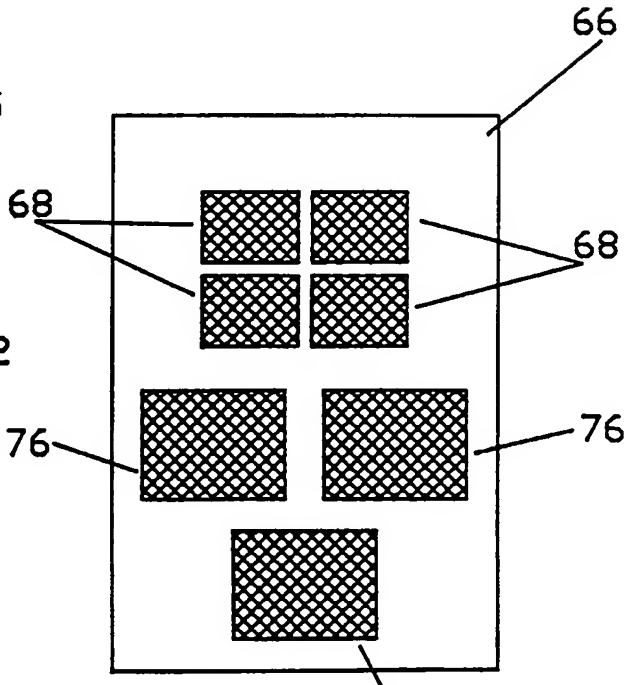

Fig.16

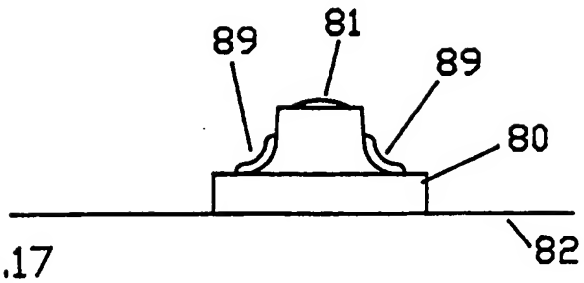

Fig.17

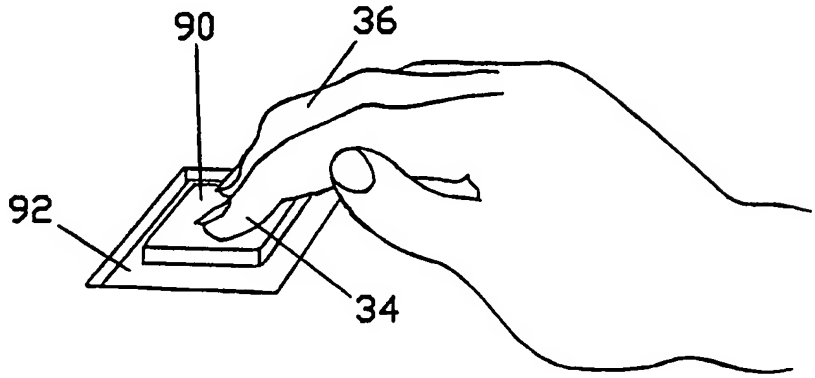

Fig.18

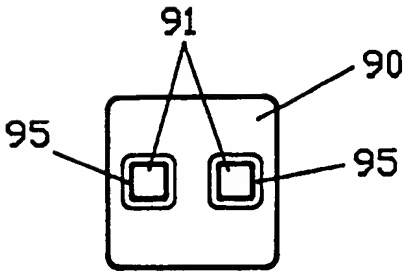

Fig.19

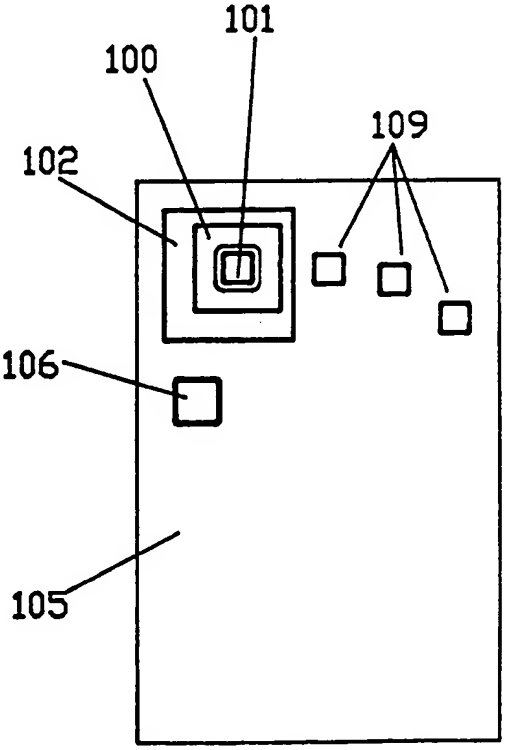

Fig.20

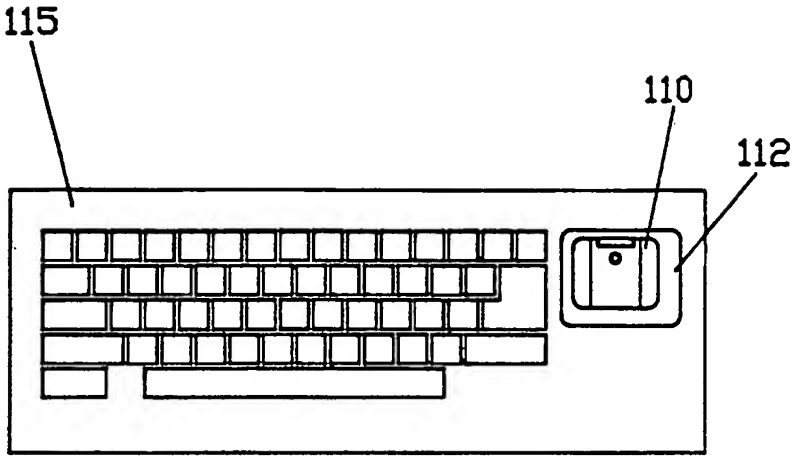

Fig.21

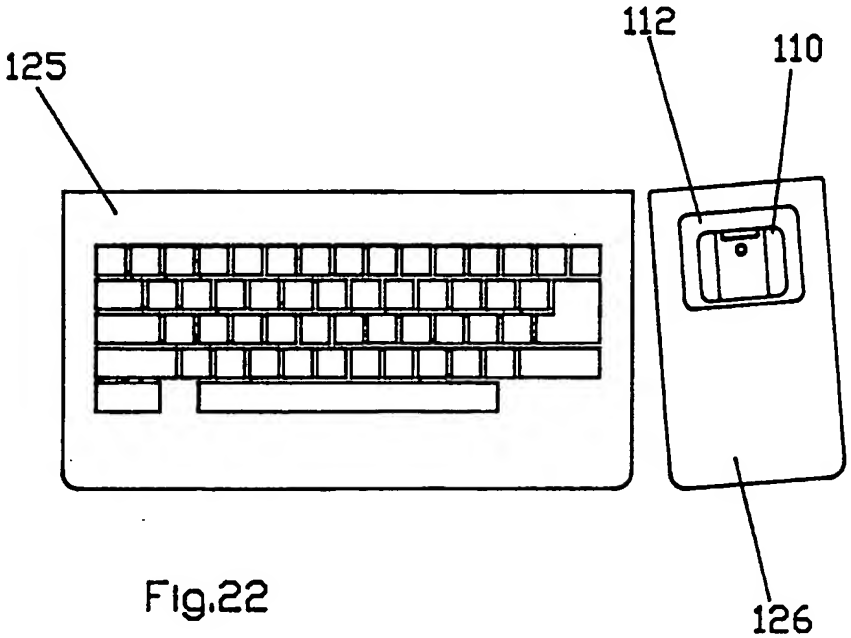

Fig.22

Capacitative Puck

The present invention relates to control devices for electronic equipment such as computers, and more particularly to puck members movable over the surface of a support member. Puck members can convert fingertip movements into electronic signals for data input to, or control of, electronic systems. They are particularly useful in association with personal computers and the pointing and position control devices for selecting and manipulating information viewed on a display screen.

There exist many computer control devices, from simple switches and potentiometers to more sophisticated items as the 'mouse', joystick, graphic tablet, trackerball and digitising pad which offer a greater degree of freedom. A specific limitation of these latter devices is that they cannot be scaled down to suit the requirements of miniaturised electronic equipment and more specifically in the field of personal computing of providing a pointing device for laptop and palmtop computers, when there is not always space on board the product or an adjacent desktop. The lightpen, the touch screen, the touch pad and the pen pad have all attempted to use a finger or a special pen directly over a surface or pad which can measure position. This surface can be transparent and placed over a display screen. All suffer from the different feel and usability to that of an ordinary hand held writing tool like a pencil, and all have filings when combined with the requirement for one or more 'click' switches to be accessed constantly while pointing.

With a view to overcoming the above disadvantages there

have been proposed various puck devices. In these the position of the puck member relative to a support is detected optically, acoustically, or electrically, e.g inductively, or by radio signals. For example, U.S 4,719,455 discloses a puck device employing optical detection for lateral movements of the puck member and pressure-sensitive resistors for detection of downward pressure on the puck.

Because an ideal puck device is small, existing detecting methods involve considerable expense. In addition separate detection methods are employed for lateral movement and for movement perpendicular thereto.

The present invention seeks to overcome or reduce one or more of the above disadvantages.

According to a first aspect of the present invention there is provided a control device for electronic equipment comprising a puck member movable on a surface of a support member wherein capacitance means are provided for detecting the position of the puck member relative to the support member.

In a preferred arrangement the puck member comprises a post extending through an aperture in the support member with plate means being mounted on the lower end of the post, the plate means carrying at least one first conductive region extending substantially parallel to the surface of the support member, and the support member carrying a plurality of further conductive regions facing said first conductive region and forming respective mutual capacitances therewith.

At least some of the further conductive regions may be

arranged on the support member in rows and columns respectively extending along two substantially perpendicular axes. This enables the position in the lateral x, y plane to be determined.

Alternatively, or in addition, at least some of the further conductive regions may be arranged orbitally on the support member. This enables the rotational position of the puck member to be determined. The further conductive regions may also be arranged radially (i.e in two or more circles of discrete regions) in which case the position in the lateral r,θ plane can be determined.

In one preferred arrangement the plate means has a substantially central conductive region and a spaced oribitally-extending conductive region, e.g of arcuate shape; to co-operate with these regions the support member has a substantially centrally arranged plurality of conductive regions arranged in rows and columns and an outer plurality of orbitally disposed conductive regions. This arrangement has the advantage of enabling both the lateral position and the rotational disposition of the puck to be determined.

Preferably the plate means is of insulating material and has an area larger than said aperture, and the first conductive region is a layer on said plate means. The plate means thus serves to prevent the puck member being removed from the support member.

In a preferred modification the puck member or a part thereof is capable of at least limited movement perpendicularly to the support member and the device further comprises means connected to said further conductive regions for detecting the magnitude of the

mutual capacitance. This enables the position of the puck member in the third (or z) dimension to be determined and can be used to produce an analogue value and/or to control a respective switch.

Spring members may be provided which tend to maintain the puck member in, or to return it to, a particular position. For example a circular puck member sitting on a circular platter can be sprung-loaded to the centre of the platter. This enables the puck device to simulate a joystick-type control.

In preferred embodiments the surface of the support member is surrounded by a raised boundary, limiting lateral movement of the puck member. The surface of the support member may become increasingly sloped towards the boundary. This provides feedback to the user in the form of an increasing feel sensation transmitted through the fingers. The interpretation of data or the control function may also be non-linear and may be related to the amount of feel.

The boundary may incorporate one or more switch means which are actuated when the puck member reaches a corresponding part of said boundary. Thus despite its small size, the puck can effect a range of different control functions.

Thus in the present invention, a pointing device takes the form of a 'puck', i.e a separate movable element, which is shaped to perform two things; firstly to generally cover at all times an open aperture underneath and secondly to provide a location for the fingertips. The puck is more commonly rectangular or circular with a scolloped form on-top to provide fingertip locations.

The puck sits on a support member in the form of a platter which can be simply a flat surface or more commonly a flat depression in a surface, the periphery faces of the depression then acting as a boundary wall.

The direction, speed and acceleration movements of the fingertips on the puck can be translated into control values by sensing technology. The sensing is done by an arrangement of capacitative sensors underneath the platter which the puck sits on. A single capacitor plate related to the puck moves across normally four fixed reference capacitor plates. The difference in capacitance values between the four plates in the presence of the moving plate can be interpreted electronically to provide precise co-ordinates of position of the puck relative to the platter. Three or two fixed capacitor plates will provide simpler co-ordinates tending to a linear positioning system and five or more would give a more complex co-ordinate arrangement possibly incorporating error correction.

There is no size limitation of the capacitance sensing as the capacitance plates can be as large or as micro sized as need be. The relative geometry of the fixed plates to the moving plate is important to be maintained in such a manner that in the extremes of position (the corner extremes of a rectangular arrangement) the moving plate aligns directly and completely over any single fixed plate to order to optimise the sensing.

The overall size of the device is related to the physical dimensions of the puck and the ability to be able to control it with a single fingertip or several fingertips. This normally means a puck face dimension of under 60mm x 50mm and platter boarder dimension of

under 90mm x 75mm.

The different arrangements whether circular or rectangular have a physical border or movement boundary. This can be used to special effect by software programs which can interpret the position close-to and on the border for instance for screen menu access.

In addition there can be a transition at the boundary wall in the form of a increasingly curved or straight ramp to provide feedback in the form of increasing feel sensation transmitted through the fingertips. One can sense when the puck is at the edge of the working area. The interpretation of data can also be non-linear and may instead be related to the mount of 'feel'. This curved ramp can be simply compensated for in the sensing method of the invention.

Switching and other variable analogue type controls can be incorporated into the puck as wiring can be led into the body from the puck through the open aperture under the puck around the pillar. Furthermore the switching and analogue information can be transferred without wires by using capacitance plates in an arrangement whereby the moving plate never goes outside of the fixed plate below. A special function to provide a squeezing type input on the puck.

In the context of computer screen cursor control, the fact that the movement of the puck is in itself constrained by a physical border or movement boundary means that the working area has a definite physical relationship to the operating zone of the computer screen cursor. The scale and resolution of the cursor movement can therefore be varied. In one form this can

be achieved with specific settings for fine, medium and coarse control resolution and in another form this can be done through variable 'zoom magnification' settings.

The movement of a cursor using the fingertip on the projection or puck is normally always under precise control with real co-ordinate positioning relative to a starting point. The capacitance sensing can be made very accurate. This makes the device suitable for precise guidance.

According to a second aspect of the invention there is provided electronic equipment incorporating a device of the above type, in which the response of the equipment becomes non-linear as the puck member approaches the edge of the support member.

Preferred embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings of which:

Figs 1,2 and 3 show perspective, plan and cross-sectional views respectively of a control device in accordance with a first embodiment;

Figs 4 and 5 show enlarged plan views of parts of the first embodiment which form a capacitance;

Figs 6,7 and 8 show perspective, plan and cross-sectional views of a control device in accordance with a second embodiment;

Figs 9,10 and 11 show perspective, plan and cross-sectional views of a control device in accordance with a third embodiment of the present invention;

Figs 12 and 13 show enlarged plan views of parts of the third embodiment which form a capacitance;

Fig.14 shows a rectangular control device in accordance with a fourth embodiment of the present invention;

Figs 15 and 16 show plan views of parts of the fourth embodiment which form a capacitance;

Fig.17 shows control device in accordance with a fifth embodiment of the present invention:

Figs 18 and 19 show perspective and plan views of a control device in accordance with sixth embodiment of the present invention;

Fig.20 shows a top plan view of an electronic device incorporating a control device in accordance with the present invention; and

Figs 21 and 22 show electronic keyboards associated with control devices in accordance with the present invention.

Referring to Fig.1 a puck 10 is constrained to move on the surface of a support in the form of a platter 12. A user's thumb and fingertips can rest in scallop 37 to hold and move the puck.

Referring to Figs 2 and 3 a pillar or post 14 is connected to the underside of puck 10 and passes through an aperture 13 in the platter 12. Connected to the other end of the pillar 14 is a puck printed circuit board (PCB) 15 with a capacitor plate 17 on it. Directly under the puck PCB is the main fixed PCB 16 with capacitor plates 18.

Referring to Figs 4 and 5, the puck PCB 15 is attached at central point 38 to the pillar and puck. The capacitor plate 17 is shown centrally located on the puck PCB. The main PCB 16 has a rectangular array of capacitor plates 18. The ratios of the respective mutual appearances with plate 17 enables the position of the puck to be precisely determined.

Referring to Fig 6, a circular puck 20 is shown in perspective on circular platter 22 with a relatively large button 21 which can be depressed with a vertical movement.

Referring to Figs 7 and 8, button 21 is sprung loaded relative to the puck 20 with a spring 28. Pillar 14 is connected at one end to the underside of the button and passes through the aperture 13 in the platter 22, and is connected at the other end to the puck PCB 15. The puck PCB and the main PCB 16 have capacitor sensors arranged, e.g as in the first embodiment. Four springs 30, with respective spring mounting 31 fixed to the platter 22, are connected to the puck PCB to make the total puck assembly sprung loaded in a way to always return to a central position relative to the platter. Also the springs return the button on the puck to the highest position relative to the puck body. Vertical movement of button 21 may control an analogue value and/or an on-off switch.

Referring to Fig 9, a circular puck 40 is shown in perspective. The configuration is arranged to input rotary information as well as positional information. One finger 34 normally rests on a 'click' switch 41 located on the top of the puck, while the other finger 36 and thumb 35 grip and rotate the puck.

Figs 10 and 11 show puck 40 resting on a circular platter 42 connected by pillar 44 through aperture 43 to the puck PCB 45 positioned over the fixed main PCB 46. There is a 'click' switch 41 on top of the puck 40. Fig.12 shows the puck PCB 45 drawn diagrammatically as circular but it can be of any convenient shape and size. Puck mounted capacitor plate 47 is centrally located on the puck PCB with rotary motion capacitor plate 54 on the periphery thereof. Fig.13 shows the main PCB 46 diagrammatically as circular, although this, too, may have any convenient shape. It has a fixed capacitor plate array 48 in the centre for positional sensing and fixed capacitor plate polar array 55 for rotational sensing.

Referring now to Fig. 14, rectangular puck 60 has three 'click' switches 69 and slides on a rectangular platter 62. Concealed under the platter are a fixed main PCB 66, and puck PCB 65. As shown in Fig.15, the puck PCB 65 has on its surface a capacitor plate 67 for positional sensing and three capacitor plates 72, one for each 'click' switch. Fig.16 shows the fixed main PCB 66 with a rectangular array of capacitor plates 68 for positional sensing and three separate capacitor plates 76 for passing switch information. In one preferred arrangement, connections from a conductive lead connected to the puck supply an electrical charge to the respective capacitor when a switch 69 is actuated. The arrangement is such that, despite movement of the puck, each plate 72 is always over part of its respective plate 76.

Referring to Fig. 17, an alternative puck 80 on a platter 82 is shown with 'click' switch 81 on-top and fingertip operated squeeze buttons 89.

Referring to Figs 18 and 19 a puck 90 on a platter 92

is shown in another alternative arrangement where fingers 34,36 rest in 'click' switch locations 95 on the puck so the puck is manoeuvred with the fingers remaining on indented switches 91. Further pressure is applied to the switch 91 to actually create a 'switch' command.

Referring to Fig.20, a single fingertip operated puck 100 is shown on a relatively small platter 102. The index fingertip rests on indented switch 101 for switching and manoeuvring. The thumb rests on a fixed large switch 106 and the other fingers rest on fixed switches 109. The complete arrangement is shown surrounded by a surface incorporating a zone 105 for the palm of the hand to rest upon.

Referring to Fig.21, a keyboard 115 has a platter 112 combined into the arrangement with a puck 110 sitting on the platter. In Fig.22, keyboard 125 has a separate housing 126 alongside for the platter 112 and puck 110. The housing can be used on the left or right hand sides of the keyboard.

The above described arrangements have numerous advantages. The lateral position of the movable puck member can be determined precisely using small capacitance detection means which are simple and cheap to construct. Moreover third-dimensional information and/or switching information or instructions can also be detected by simple capacitative means. The control device can be easily electrically screened to eliminate interference.

By avoiding the need for wires to make connections between the puck p.c.b. and the fixed p.c.b., the puck can move freely with minimal physical resistance to its motion.

Numerous modifications can be made to the above described arrangements. For example the platter may carry the first conductive region and the puck the further conductive regions; here a position data output would be taken from the puck.

Instead of being planar the bottom of the puck and the upper surface of the platter may have a common radius of curvature.

The puck may have any convenient shape in plan view e.g hexagonal or octagonal. and the platter surface may have a similar or different shape.

Although the invention has been described in connection with a puck device, the position of a joystick, trackerball or mouse type control device may be detected capacitatively. In addition to detecting lateral and rotational movements, capacitors can also be used to detect roll and pitch movements of the control device, thus making it suitable for flight simulation.

Claims

1. A control device for electronic equipment comprising a puck member movable on a surface of a support member wherein capacitance means are provided for detecting the position of the puck member relative to the support member.

2. A device according to claim 1 wherein the puck member comprises a post extending through an aperture in the support member with plate means being mounted on the lower end of the post, the plate means carrying at least one first conductive region extending substantially parallel to the surface of the support member, and the support member carrying a plurality of further conductive regions facing said first conductive region and forming respective mutual capacitances therewith.

3. A device according to claim 2, wherein at least some of the further conductive regions are arranged on the support member in rows and columns respectively extending along two substantially perpendicular axes.

4. A device according to claim 2 or 3, wherein at least some of the further conductive regions are arranged orbitally on the support member.

5. A device according to any of claims 2 to 4, wherein the plate means is of insulating material and has an area larger than said aperture, and wherein the first conductive region is a layer on said plate means.

6. A device according to any of claims 2 to 5 wherein the puck member or a part thereof is capable of at least limited movement perpendicularly to the support

member and the device further comprises means connected to said further conductive regions for detecting the magnitude of the mutual capacitance.

7. A device according to any preceding claim wherein spring members are provided which tend to maintain the puck member in, or to return it to, a particular position.

8. A device according to any preceding claim wherein the surface of the support member is surrounded by a raised boundary, limiting lateral movement of the puck member.

9. A device according to claim 8 wherein the surface of the support member becomes increasingly sloped towards said boundary.

10. A device according to claim 8 or 9 wherein the boundary incorporates one or more switch means which are actuated when the puck member reaches a corresponding part of said boundary.

11. A device according to any preceding claim wherein the movable puck member comprises one or more capacitance switches.

12. A device substantially as herein described with reference to Figs 1 to 5, Figs 6 to 8, Figs 9 to 13, Figs 14 to 16, Fig.17, Figs 18 and 19, Fig 20, Fig.21, or Fig.22 of the accompanying drawings.

13. Electronic equipment incorporating a device according to any preceding claim wherein the response of the equipment becomes non-linear as the puck member approaches the edge of the support member.

14. Electronic equipment incorporating an arrangement of four or five control devices arranged to be controlled by the fingers or fingers and thumb of a hand, at least one of the control devices being in accordance with one of claims 1 to 12.

15. Electronic equipment substantially as herein described.

16. A control device for electronic equipment comprising a puck member movable on a surface of a support member which becomes increasingly sloped toward its edges.

17. Electronic equipment incorporating a control device comprising a puck member movable on a surface of a support member, wherein the response of the equipment becomes non-linear as the puck member approaches the edge of the support member.

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